Transportation Electrification Cost-Benefit Analysis for Public Service Company of Colorado

SUMMARY REPORT

PREPARED BY

J. Michael Hagerty
Sanem Sergici
Ryan Hledik
Ethan Snyder
Julia Olszewski
Jadon Grove

PREPARED FOR

Public Service Company of Colorado

May 2023

Brattle

Xcel Energy®

NOTICE

- This report was prepared for Public Service Company of Colorado in accordance with The Brattle Group's engagement terms, and is intended to be read and used as a whole and not in parts.
- The report reflects the analyses and opinions of the authors and does not necessarily reflect those of The Brattle Group's clients or other consultants.
- There are no third-party beneficiaries with respect to this report, and The Brattle Group does not accept any liability to any third party in respect of the contents of this report or any actions taken or decisions made as a consequence of the information set forth herein.

TABLE OF CONTENTS

Executive Summary

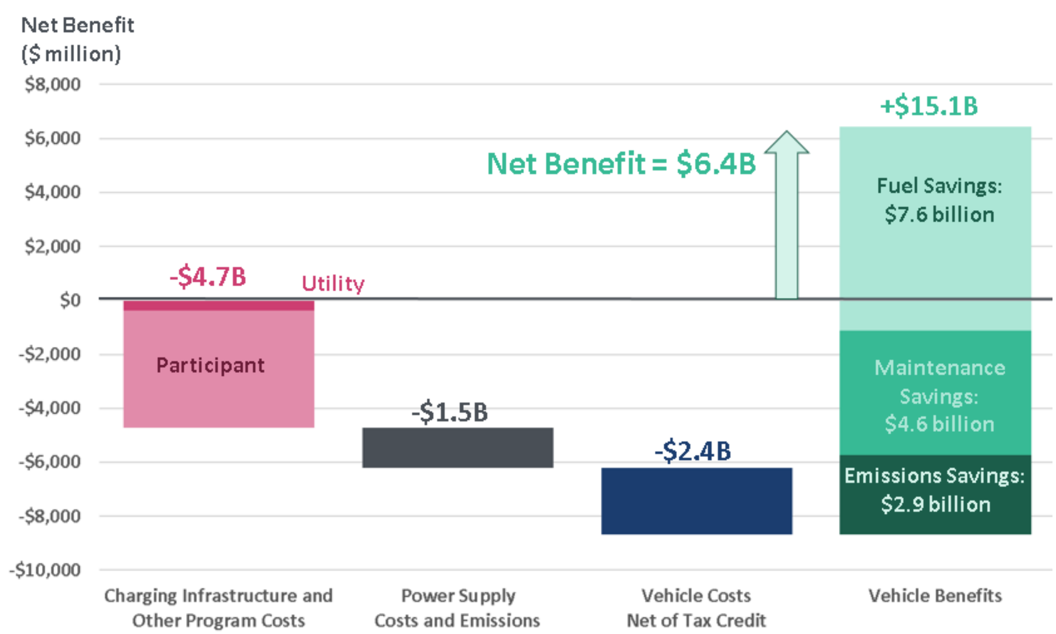
In 2018 Colorado set a statewide goal of reaching 940,000 light duty electric vehicles (EV) on the road by 2030 and recently reaffirmed the 2030 goal in the Colorado 2023 EV Plan. To support Colorado in meeting its EV deployment goals, Public Service Company of Colorado (Public Service) initially developed in 2020 its 2021–2023 Transportation Electrification Plan (TEP) and is currently seeking approval for its 2024–2026 TEP. To that end, Public Service engaged consultants at The Brattle Group to evaluate the costs and benefits of adoption of EVs and corresponding charging infrastructure in Public Service's territory consistent with the State's transportation electrification objectives reflected in the Colorado 2023 EV Plan. The objective of the study is to inform the Colorado Public Utilities Commission (PUC) and Public Service stakeholders on the expected costs of reaching the 2030 transportation electrification goal and the benefits that result from electrification within Public Service's territory, accounting for the costs of the 2024–2026 TEP.

We analyze the costs and benefits of transportation electrification within Public Service's territory using three cost effectiveness tests, consistent with prior analysis submitted to the PUC. The Societal Cost Test (SCT) is the primary cost effectiveness test applicable for transportation electrification as the Colorado Revised Statutes require that Public Service develop programs "to support widespread transportation electrification" that seek to "minimize overall costs and maximize overall benefits." Societal costs and benefits include the charging infrastructure costs incurred by the utility and participants, the incremental vehicle costs of EVs, the costs of electricity supply for charging vehicles, the avoided costs of fuel consumption, the avoided maintenance costs, and the avoided costs of greenhouse gas (GHG), including carbon dioxide and methane, and other air pollutant emissions. The Participant Cost Test (PCT) and the Ratepayer Impact Measure (RIM) tests take a narrower perspective, analyzing the net benefits specifically for "participants" (e.g., EV drivers and charger developers) in the PCT and Public Service ratepayers in the RIM. For each test, we analyze the annual costs and benefits of transportation electrification within Public Service's territory over a 20-year period and calculate the present value of net benefits using applicable discount rates.

To assess the costs and benefits of transportation electrification, we utilize the Guidehouse "2030 State Target" forecast for EV and charging infrastructure in Public Service's territory that meets the statewide 2030 objectives, including about 499,000 personally-owned electric light duty vehicles (LDVs) and 46,000 commercially-owned electric LDVs, medium duty vehicles (MDVs), and heavy duty vehicles (HDVs) by 2030. We estimate the incremental costs of EV adoption and charger deployment consistent with the 2030 state goal, including Public Service's proposed 2024–2026 TEP programs and the costs incurred by EV drivers and charger developers. We then estimate the costs of increased electricity supply and air emissions to serve EV charging demand and the benefits of reduced vehicle fuel costs, maintenance costs, and societal emissions costs. To quantify these impacts, we rely on power system forecasts from Public Service's recent resource planning studies, other Colorado-specific sources where possible, and other widely-cited, publicly available sources. In cases where public sources were not available, we develop assumptions tailored to their system. All key methodological assumptions and data sources are summarized in the Appendices to this report.

We estimate that transportation electrification in Public Service's territory results in a positive net benefit of $6.4 billion based on the Societal Cost Test. The drivers of transportation electrification net benefits are avoided fuel costs, avoided maintenance costs, and avoided emissions costs from increased EV adoption, as shown in Figure ES-1 below. Over the 20-year timeframe of the analysis, transportation electrification reduces cumulative carbon dioxide emissions by about 26 million metric tons.

FIGURE ES-1: TRANSPORTATION ELECTRIFICATION SOCIETIAL COST TEST NET BENEFITS



Our findings are robust across a range of alternative assumptions in our analysis. For the key drivers of the results, we establish plausible high- and low-sensitivity assumptions and analyze the change in the net benefits attributable to each. None of the sensitivity assumptions results in negative net benefits. Net benefits are most sensitive to the social cost of carbon and fuel prices on the high end, and the maintenance cost savings and vehicle costs on the low end. For example, lower maintenance cost savings assumptions reduce societal net benefits by $3.1 billion, while higher fuel price assumptions increase societal net benefits by $4.4 billion.

I. Introduction

Public Service Company of Colorado (Public Service) requested that we evaluate the impact of the adoption of electric vehicles (EVs) and corresponding charging infrastructure in Public Service's territory consistent with the state of Colorado's Electric Vehicle Plan statewide goal of 940,000 light duty EVs by 2030. The objective of the study is to inform stakeholders on the expected costs of reaching the 2030 transportation electrification goal and the benefits that result from electrification within Public Service's territory. The study incorporates the costs of the 2024–2026 Transportation Electrification Plan (TEP) proposed by Public Service to support the State of Colorado's EV goal.

II. Cost-Benefit Methodology

A. Cost Effectiveness Framework

We completed the cost-benefit analysis (CBA) using three cost effectiveness tests that evaluate the impacts of transportation electrification within Public Service's territory from alternative perspectives. The Societal Cost Test (SCT) is the primary cost effectiveness test applicable for transportation electrification impacts as the Colorado Revised Statutes require that Public Service develop programs "to support widespread transportation electrification" that seek to "minimize overall costs and maximize overall benefits."[1] The SCT incorporates the overall costs and the overall benefits of transportation electrification by including its impacts on a societal level, together with the costs of the programs incurred by the utility and participants, the incremental vehicle costs of EVs, the costs of electricity supply for charging vehicles, the avoided costs of fuel consumption, the avoided maintenance costs, and the avoided costs of greenhouse gas (GHG) and other air pollutant emissions.

[1] Section 40-5-107(1)(b), C.R.S.

The Participant Cost Test (PCT) and the Ratepayer Impact Measure (RIM) tests take a narrower perspective on EV adoption than the SCT, analyzing the costs incurred specifically by the participants in EV adoption, including EV owners, property owners, and independent charging station developers, in the PCT or by Public Service ratepayers in the RIM.[2] Notably, neither of these tests include the societal benefits of reduced emissions of GHGs and other air pollutants. We completed these additional cost effectiveness tests for consistency with previous TEP cost-benefit studies and to provide additional information for the Commission's consideration.

We analyzed the annual costs and benefits of transportation electrification within Public Service's territory over a 20-year period (2024 to 2043), including the costs of replacing vehicles and charging infrastructure with an expected asset life of less than 20 years. This timeframe was set for the CBA to include the full life of vehicles and charging infrastructure adopted from 2024 to 2030. We then calculated the present value of each cost and benefit using a societal discount rate of 4.76% for the SCT and Public Service's after-tax weighted average cost of capital (ATWACC) of 6.42% for the PCT and RIM.[3] Finally, we calculated the net present value across the applicable costs and benefits.

B. Quantified Costs & Benefits

We evaluated a comprehensive set of costs and benefits of transportation electrification in Public Service's territory. Table 1 below shows directional impacts of the costs and benefits quantified for each of the cost effectiveness tests.

2 In this analysis, "participants" refer to all participants in transportation electrification and are not limited to participants in utility programs.

3 See Appendix A for details on the societal discount rate.

TABLE 1: QUANTIFIED COSTS AND BENEFITS

Component	Societal Cost Test	Participant Cost Test	Ratepayer Impact Measure
Utility Charging Infrastructure and Other Program Costs	Cost	No Impact	Cost
Utility Incentive/Rebate	No Impact	Benefit	Cost
Participant Charging Infrastructure Costs	Cost	Cost	No Impact
Incremental Vehicle Cost	Cost	Cost	No Impact
Electricity Supply Costs	Cost	No Impact	Cost
Electricity Emissions Costs	Cost	No Impact	No Impact
Electricity Bill Payments	No Impact	Cost	Benefit
Vehicle Fuel Savings	Benefit	Benefit	No Impact
Vehicle Maintenance Savings	Benefit	Benefit	No Impact
Vehicle Emissions Savings	Benefit	No Impact	No Impact

Below we describe each of the cost and benefit components quantified, along with brief summaries of the methodology to calculate their impacts. See Appendices A and B for additional detail on the CBA assumptions.

CHARGING INFRASTRUCTURE COSTS

Charging infrastructure costs include the capital and operation and maintenance (O&M) costs for the electric vehicle supply equipment (EVSE) and electric vehicle supply infrastructure (EVSI) needed for serving EV charging demand. To estimate the costs of charging infrastructure needed in Public Service's territory, we utilize the EV charging infrastructure forecast developed by Guidehouse based upon the EV adoption projected to be necessary to achieve Colorado's policy goals.[4] We assume that a portion of the EVSE and EVSI needed to meet future EV charging demand will be deployed by Public Service as proposed in the 2024–2026 TEP. The additional chargers needed by 2030 to meet EV charging demand will be deployed by EV drivers, property owners, and independent charger developers, who we collectively refer to as "participants."

[4] See Section II.D for further information on the Guidehouse forecasts.

Public Service developed cost estimates for the EVSE and EVSI required for each type of charger projected by Guidehouse. The 2024–2026 TEP program costs include the capital costs for equipment and installation of EVSE and EVSI, program administration costs, information technology costs, ongoing O&M costs, and rebates provided to participants for charging equipment. We estimate the participant charging infrastructure costs by utilizing Public Service's projected EVSE and EVSI costs. We include the costs for chargers deployed starting in 2024, and assume that all EVSE and EVSI are replaced at the end of their 10-year useful life. We account for the availability and value of federal tax credits that lower the costs of charging infrastructure for Public Service and other EV adopters.

VEHICLE COSTS

Vehicle costs represent the cost premium of purchasing an EV instead of an internal combustion engine (ICE) vehicle. We estimate the incremental vehicle costs for each vehicle type, including personal LDVs, commercial LDVs, and medium duty vehicles (MDV) and heavy duty vehicles (HDV), based on cost projections in the Colorado Light-Duty Vehicle Electrification Roadmap for LDVs and a recent U.S. Department of Energy report for MDVs and HDVs.[5] We include the costs of vehicle rebates proposed by Public Service in its 2024–2026 TEP in the PCT and RIM tests. We account for the availability and value of federal tax credits that lower the vehicle costs for EV adopters.

We utilize the Guidehouse forecast developed for Public Service of cumulative EV adoption through 2030 that achieves the state policy goals.[6] We include the incremental costs for EVs adopted starting in 2024 and assume that participants replace EVs at the end of their useful lifespan, which is modeled as 12 years for personal vehicles, five years for commercial LDVs, and 10 years for MDVs and HDVs.

ELECTRICITY SUPPLY AND EMISSIONS COSTS

Electricity supply costs include all incremental costs for supplying the electricity required to meet the projected EV charging demand. The electricity supply costs include generation production costs (i.e., fuel and variable O&M), renewable energy procurement costs, and generation, transmission, and distribution capacity costs. To calculate the incremental

[5] Colorado Energy Office, Colorado Light-Duty Vehicle Electrification Roadmap, April 2022, p. 127; U.S. Department of Energy, 2022 Incremental Purchase Cost Methodology and Results for Clean Vehicles, December 2022, p. 6. Incremental costs of commercial light trucks also are obtained from the DOE report.

[6] See Section II.D for further information on the Guidehouse forecasts.

generation production costs, we use projected hourly marginal costs of generation for 2024 to 2043 that Public Service provided based on its internal resource planning modeling for the February 2023 Update to the Clean Energy Plan.[7] Public Service provided the incremental costs of serving higher peak demand, including generation capacity costs and transmission and distribution costs based on long-run marginal costs included in its current tariff. We also include the costs to procure additional renewable generation to meet the incremental charging demand in alignment with Public Service's goal to supply customers with at least 80% of its electricity demand from renewables by 2030.

Electricity emissions costs reflect the social externalities associated with combustion-related GHG emissions, including carbon dioxide (CO_2) and methane, and criteria air pollutants, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), and fine particulate matter (PM2.5), from electricity generation facilities. We use the average generation emissions rates provided by Public Service for CO_2, methane, SO_2, and NO_x. We estimate the emissions rate of PM2.5 for Public Service's generation fleet using data from the U.S. Environmental Protection Agency's (EPA) AVERT model.[8]

We rely on the social cost of carbon emissions estimated in the most recent Interagency Working Group on Social Cost of Greenhouse Gases report using a 2.5% real discount rate, in line with recent precedent by Public Service.[9] The societal cost of criteria air pollutants (SO_2, NO_x, PM2.5) are based on estimates used by the National Highway Transportation Safety Administration (NHTSA) in its proceedings related to the updated Corporate Average Fuel Efficiency (CAFE) standards, which include values for both electricity generation emissions and vehicle emissions.[10]

ELECTRICITY BILL PAYMENTS

We estimate the incremental electricity bill payments by participants due to EV charging for the PCT and RIM tests based on the all-in retail rates calculated by Public Service over the twenty-year study period. Specifically, we use Residential Energy Time-of-Use Service rate (Schedule RE-TOU) for residential charging, Secondary Voltage Time-of-Use–Electric Vehicle Service

7 Xcel Energy, Colorado's Clean Energy Plan: February 2023 Update, February 2023.

8 U.S. Environmental Protection Agency, Avoided Emissions and generation Tool (AVERT), 2022.

9 Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates under Executive Order 13990, February 2021.

10 National Highway Traffic Safety Administration, Technical Support Document: Final Rulemaking for Model Years 2024-2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards, March 2022.

Critical Peak Pricing Rate (Schedule S-EV-CPP) for workplace and fleet charging, Secondary Voltage Time-of-Use–Electric Vehicle Service (Schedule S-EV) for all public L2 charging and non-utility Direct Current Fast Charging (DCFC), and DCFC Station Rates at Company Owned Stations (Schedule EVC) for utility-owned DCFC charging.[11] For the participants of charger or battery services, bill payments also include monthly participation fees for the use of utility-owned equipment.

VEHICLE FUELS, MAINTENANCE AND EMISSIONS SAVINGS

To estimate the benefits of incremental EV adoption, we calculate the avoided fuel costs, avoided maintenance costs, and avoided emissions costs by replacing similar ICE vehicles. We estimate the ICE vehicle mileage and efficiency using the vehicle type-specific assumptions shown in Table B-1 in Appendix B. Fuel prices are based on projected wholesale motor gasoline price from the Energy Information Administration's (EIA) 2023 Annual Energy Outlook, which excludes distribution costs and federal and local taxes, consistent with the use of wholesale electricity costs for electricity supply costs.[12] Avoided maintenance costs are from Argonne National Laboratory's Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) model.[13] To estimate avoided fuel emissions, we rely on the GHG emissions rates for gasoline reported by the EIA[14] and EPA's criteria pollutant emissions standards for new vehicles.[15]

C. Analytical Approach

We analyze the costs and benefits of transportation electrification using a five-step approach, as illustrated in Figure 1 shown below.

11 EV drivers charging at non-utility DCFC will pay rates set by the charger owner. We assume that a portion of those rates will be paid to Public Service by the charger owner at the Schedule S-EV rate (and included in the PCT and RIM tests). The remaining rates will support cost recovery of the charging infrastructure and are not included in the PCT and RIM tests, as the costs of the charging infrastructure are already included under "Charging Infrastructure Costs".

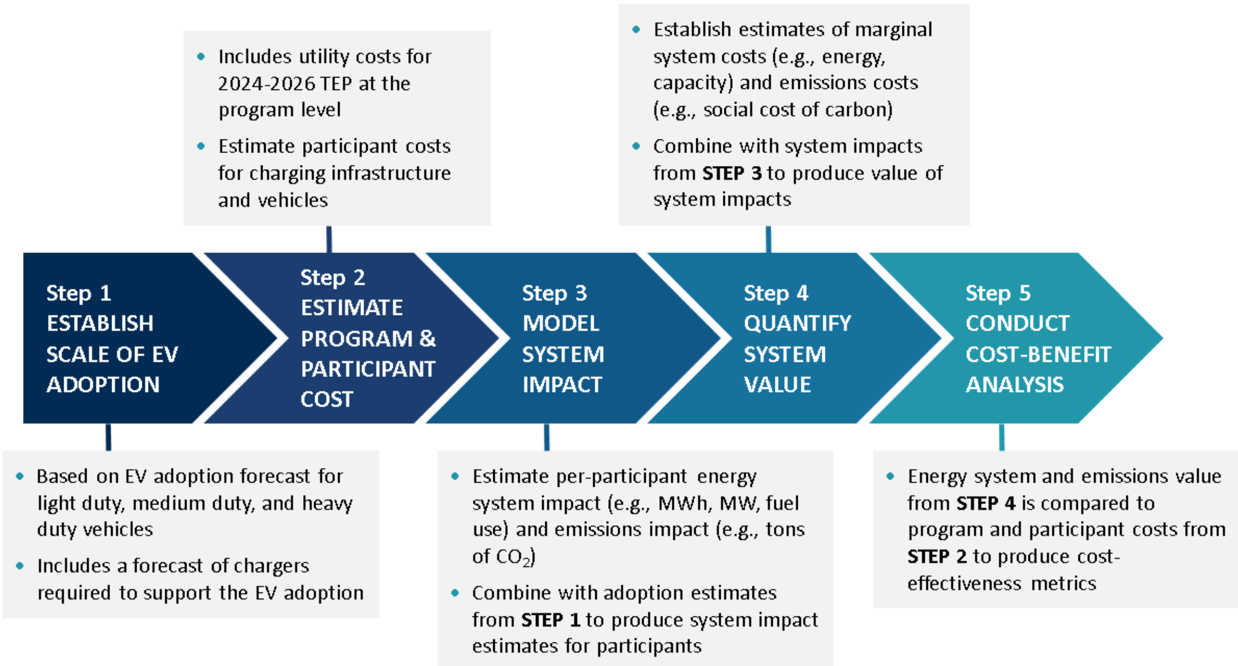
12 U.S. Energy Information Administration, Annual Energy Outlook 2023, Table 57.8.

13 Argonne National Laboratory, AFLEET Tool—Argonne National Laboratory (anl.gov).

14 U.S. Energy Information Administration, Carbon Dioxide Emissions Coefficients, October 2022.

15 U.S. Environmental Protection Agency, Light Duty Vehicle Emissions, accessed November 1, 2022;

FIGURE 1: CBA METHODOLOGY



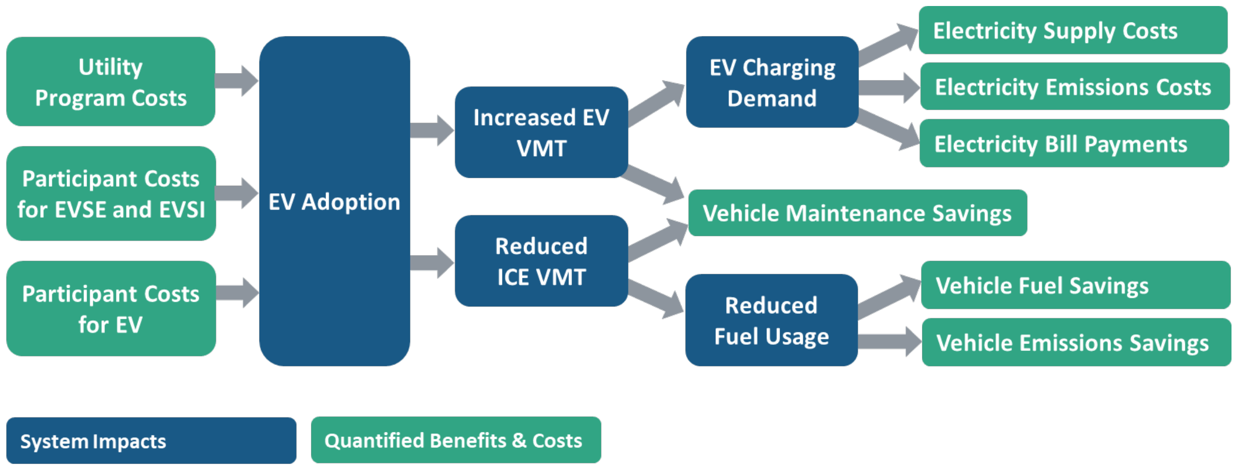
The first step is to **establish the scale of EV adoption**. From Guidehouse, we obtain the EV adoption forecast for Public Service's territory for various EV types, as well as number of chargers needed to support the projected EV adoption. Details regarding the forecast are provided in the next section below.

The second step is to **estimate the program and participant costs**. This step includes estimating the participant and utility costs for the charging infrastructure as well as the upfront and ongoing maintenance costs to participants of EVs compared to ICE vehicles. As noted earlier in this chapter, Public Service developed total cost estimates for each program included in the 2024–2026 TEP.

The third step is to **model the system impact**. The system impact of transportation electrification includes impacts on the energy system, such as changes in consumption of electricity, gasoline, and other fuels. These impacts also include changes in emissions, including CO_2, methane, SO_2, NO_x, and PM2.5.

The fourth step is to **quantify the system value**. In the case of energy system impacts, system value is represented by the marginal incremental cost of electricity generation and electricity infrastructure investment, and avoided transportation fuels. In the case of environmental and emissions benefits, we value the avoided social cost of changes in emissions. We then calculate energy system value and emissions value by multiplying the system impacts from step 3 by these marginal cost forecasts. Figure 2 below illustrates the approach we use to estimate how EV adoption replaces miles driven by ICE vehicles with miles driven by EVs and results in vehicle and system impacts included in the CBA.

FIGURE 2: CBA MODEL FLOW DIAGRAM



Notes: Utility program costs include charging infrastructure costs and rebates, vehicle rebates, and other program costs proposed in the 2024–2026 TEP.

The fifth step is to **conduct the cost-benefit analysis** by comparing the change in system value from step 4 to the program costs from step 2. Cost-effectiveness is measured as the net present value of the portfolio over a 20-year study horizon, which is the present value of the benefits net of the program costs. We perform a sensitivity analysis for key assumptions in the analysis, developing alternative low and high estimates for each major assumption representing outcomes that are plausible but less likely than the base assumption. One-by-one, we estimate how the net benefits of transportation electrification change by repeating the steps above with that single assumption changed to the high or low value. This provides both an indication of the overall sensitivity of the portfolio's cost effectiveness to the assumptions as well as an indication of the relative importance of each assumption to the findings.

D. Electrification Adoption and Charging Infrastructure Needs

EV and charging infrastructure adoption within Public Service's territory is based on projections prepared by Guidehouse.[16] The projections are consistent with Colorado's goal of increasing the number of statewide electric LDVs to 940,000 by 2030. For the purposes of this analysis, we

[16] Guidehouse, Colorado EV and Charging Needs Forecast, May 2023.

assume cumulative adoption of EVs increases through 2030 and then remains constant for the remainder of the 20-year study period. Table 2 below summarizes the EV adoption projections utilized in our analysis.

TABLE 2: EV ADOPTION PROJECTIONS FOR PUBLIC SERVICE'S TERRITORY

	2024	2025	2026	2027	2028	2029	2030
Cumulative Adoption							
Personal LDVs	132,230	178,368	230,109	287,297	351,287	421,971	498,510
Commercial LDVs	10,984	14,961	19,356	24,145	29,443	35,279	41,555
MDVs	633	907	1,210	1,542	1,900	2,283	2,689
HDVs	369	514	676	855	1,050	1,261	1,486
School Buses	0	14	34	34	34	34	34
Total	**144,216**	**194,764**	**251,384**	**313,872**	**383,714**	**460,828**	**544,273**
Annual Adoption							
Personal LDVs	40,881	46,138	51,741	57,188	63,990	70,684	76,539
Commercial LDVs	3,583	3,978	4,394	4,789	5,299	5,836	6,276
MDVs	243	274	303	332	358	383	406
HDVs	126	145	162	179	195	211	225
School Buses	0	14	20	0	0	0	0
Total	**44,834**	**50,548**	**56,620**	**62,488**	**69,842**	**77,114**	**83,445**

Sources and Notes: Guidehouse Colorado EV and Charging Needs Forecast prepared for Public Service (2030 State Target Scenario) except the school bus forecast, which is based on programs proposed in Public Service's 2024–2026 TEP.

We similarly utilize the EV charging infrastructure needs forecast from Guidehouse. The projections include a mix of Level 1, Level 2, and DCFC chargers at public and private locations. Table 3 below shows the projected charging infrastructure needs within Public Service's territory.

TABLE 3: CHARGING INFRASTRUCTURE NEEDS IN PUBLIC SERVICE'S TERRITORY (# OF PORTS)

	2024	2025	2026	2027	2028	2029	2030	2031
Personal Vehicle Chargers								
L1	58,272	75,355	93,022	110,907	129,210	147,522	165,199	181,435
SFH L2	65,930	89,137	115,254	144,224	176,745	212,786	251,945	293,455
MFH L2	1,088	1,691	2,470	3,444	4,651	6,115	7,849	9,848
Public L2	10,554	13,451	16,300	18,977	21,457	23,609	25,270	26,265
DCFC	2,299	3,057	3,866	4,721	5,638	6,607	7,603	8,593
Total	**138,143**	**182,691**	**230,912**	**282,272**	**337,701**	**396,639**	**457,865**	**519,596**
Commercial Vehicle Chargers								
Fleet L2	743	974	1,211	1,449	1,692	1,939	2,179	2,401
Fleet DCFC	675	913	1,169	1,415	1,677	1,953	2,234	2,508
School Bus L2	10	13	17	21	25	29	33	37
School Bus DCFC	0	14	34	34	34	34	34	34
Total	**1,427**	**1,914**	**2,430**	**2,919**	**3,429**	**3,955**	**4,480**	**4,980**

Sources and Notes: Guidehouse Colorado EV and Charging Needs Forecast prepared for Public Service (2030 State Target Scenario) except the school bus DCFC forecast which is based on programs proposed in Public Service's 2024–2026 TEP.

E. TEP Programs Included in Cost-Benefit Analysis

Public Service's 2024–2026 TEP programs include EV charger deployment programs, vehicle incentive programs, a distribution system upgrade program, managed charging programs, public research innovation (PRI) programs, and other incentives to support transportation electrification. We include the costs of the 2024–2026 TEP programs listed below in Table 4 with the programs split into two categories: Personal Vehicle Programs and Commercial Vehicle Programs.

TABLE 4: PUBLIC SERVICE 2024–2026 TRANSPORTATION ELECTRIFICATION PLAN OVERVIEW

Program	Program Description	Program Scale	Program Capital Cost
Personal Vehicle Program Category			
Residential L2 Chargers	$500-$1,700 rebate for L2 charger installation and/or utility-built L2 charger with monthly fee	11,574	$14.3 million
MFH L2 Chargers	Rental of L2 charger with monthly fee, and utility construction of EVSI	668	$7.1 million
MFH DCFCs	Utility construction of EVSI for DCFCs	97	$3.5 million
MFH L2 Charger New Construction Rebate	$1,383 weighted average rebate for L2 chargers	312	$0.4 million
Workplace L2 Chargers	$2,500 rebate or utility construction of L2 charger with monthly fee, and utility construction of EVSI	446	$6.0 million
Workplace L2 Charger New Construction Rebate	$1,383 weighted average rebate for L2 chargers	291	$0.4 million
Public L2 Chargers	Utility construction of EVSI for L2 chargers	101	$2.2 million
Public DCFCs	Utility construction of EVSI and EVSE for DCFCs	578	$120.3 million
IQ Vehicle Rebate	$5,500 rebate for new EVs and $3,000 for used EVs by income-qualified (IQ) customers	1,181	$6.1 million
Charging Perks	Dynamic optimized managed charging program.	23,561	n/a
Optimize Your Charge	Static optimized managed charging program.	4,529	n/a
Commercial Vehicle Program Category			
Fleet L2 Chargers	$2,500 rebate or construction of L2 charger with monthly fee, and utility construction of EVSI	228	$3.0 million
Fleet DCFCs	Utility construction of EVSI and EVSE for DCFCs at public locations	192	$7.0 million
Fleet L2 Charger New Construction Rebate	$1,383 weighted average rebate for L2 chargers	148	$0.2 million
School Bus DCFCs	Utility construction of EVSE and EVSI for DCFCs	34	$6.9 million
School Bus Vehicle Rebate	Rebate for the purchase of electric school buses.	34	$13.6 million
TNC Fleet Vehicle Rebate	Rebate for the purchase of electric vehicle to TNC drivers/companies.	1,786	$9.5 million
Municipal Fleet Vehicle Rebate	Rebate for the purchase of electric vehicle by municipal fleets.	2,996	$19.5 million
Distribution Upgrades for Fleet Electrification	Distribution upgrades to serve future MHDV charging locations.	n/a	$50.0 million
Innovation	Vehicle and charger rebates for MHDVs.	n/a	$22 million
Other	IT and other investments	n/a	$53 million
TEP (2024-2026) Total			**$345 million**

III. Key Findings

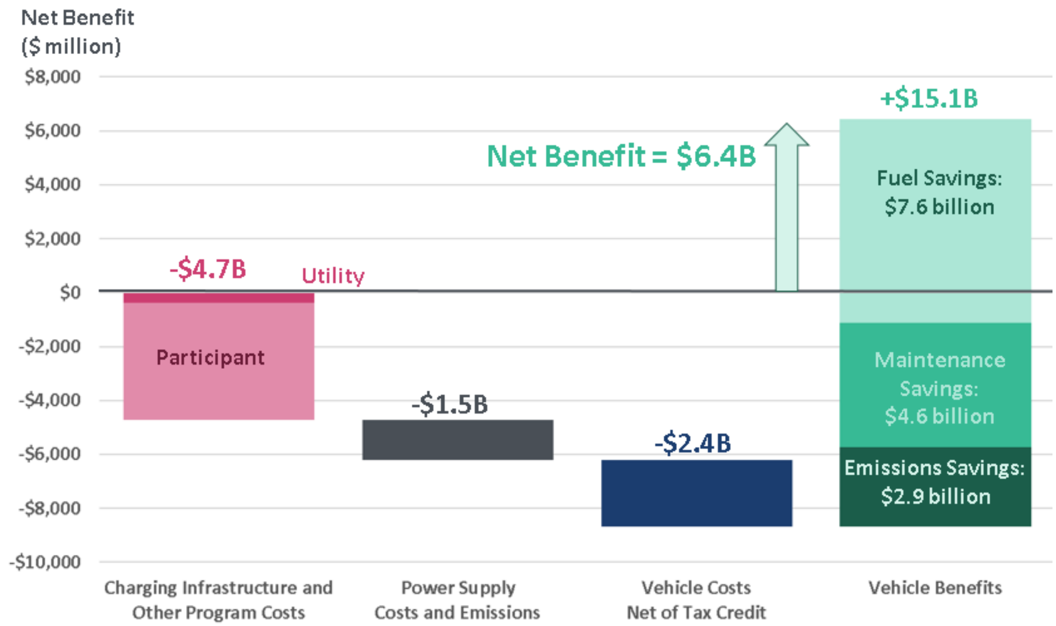
We estimate that the adoption of transportation electrification in Public Service's territory will result in societal net benefits of $6.4 billion. The net benefits are split between the Personal Vehicle ($4.5 billion) and Commercial Vehicle ($1.9 billion) categories. In addition, transportation electrification results in net benefits for the PCT of $2.0 billion and the RIM of $1.1 billion.

TABLE 5: 2030 STATE GOAL TRANSPORTATION ELECTRIFICATION NET BENEFIT SUMMARY

Vehicle Type	Societal Cost Test	Participant Cost Test	Ratepayer Impact Measure
Personal Vehicles	$4,539 million	$1,273 million	$911 million
Commercial Vehicles	$1,905 million	$680 million	$150 million
Total	$6,444 million	$1,953 million	$1,061 million

Figure 3 below shows the detailed breakdown of the primary SCT components for overall transportation electrification. Our analysis finds total incremental costs of $8.6 billion primarily due to EV charging infrastructure costs ($4.7 billion) and vehicle costs ($2.4 billion), both net of current federal tax credits. Incremental power supply adds $1.5 billion to societal costs. The primary benefits of transportation electrification are avoided gasoline and diesel costs ($7.6 billion) and avoided maintenance costs ($4.6 billion) with $2.9 billion in societal benefits for reduced GHG and criteria air pollutant emissions.

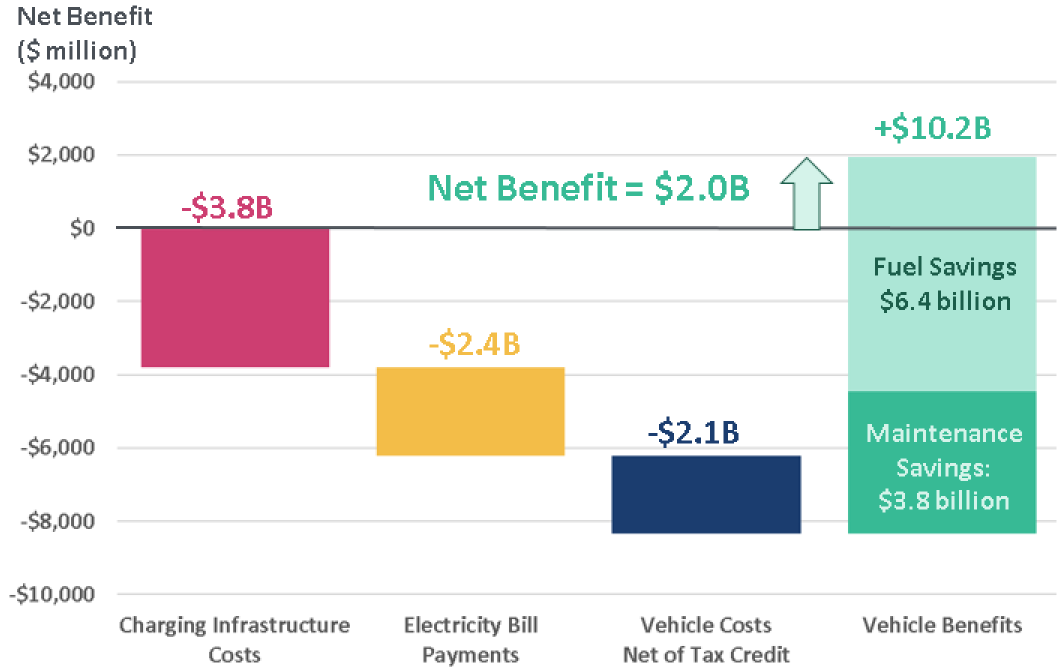
FIGURE 3: TRANSPORTATION ELECTRIFICATION SOCIETAL COST TEST RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the nominal societal discount rate of 4.76%. Charging infrastructure costs include both EVSE and EVSI costs.

Figure 4 below shows transportation electrification in Public Service's territory results in $2.0 billion of net benefits to participants. We estimate participants will save $10.2 billion through and fuel savings and reduced maintenance costs. This benefit will be offset by $8.3 billion in charger infrastructure costs, vehicle costs, and increased electricity bill payments to charge the EVs. From the participant's perspective, upfront costs for purchasing an EV and installing charging infrastructure are offset over time by decreased fuel and maintenance costs.

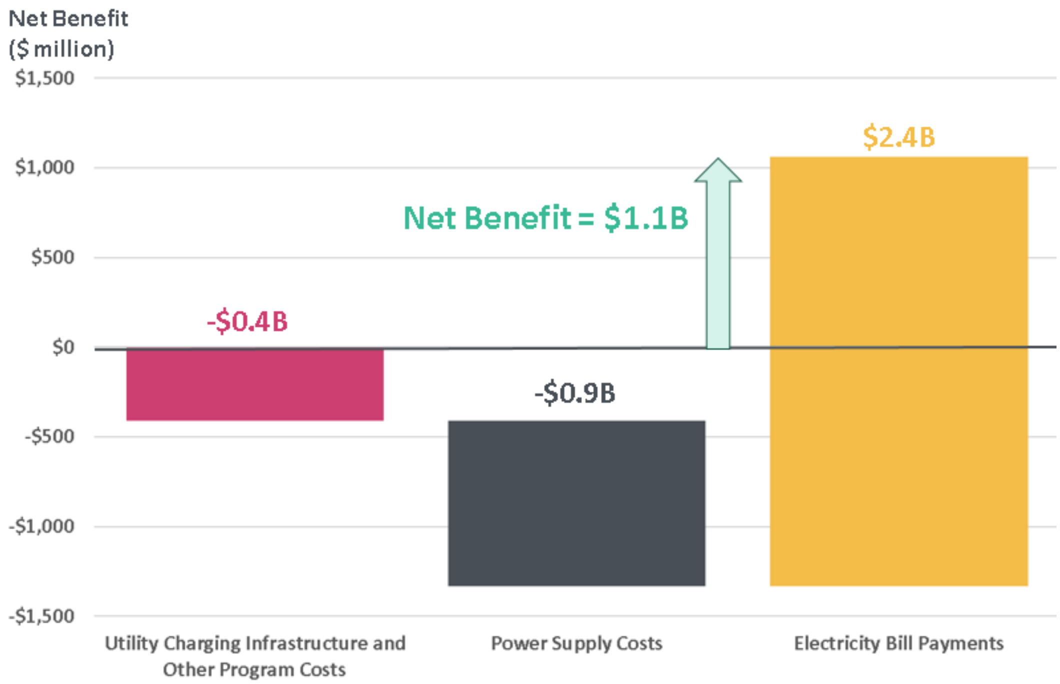
FIGURE 4: TRANSPORTATION ELECTRIFICATION PARTICIPANT COST TEST RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.

Figure 5 below shows that transportation electrification results in net benefits of $1.1 billion for Public Service ratepayers. Ratepayers benefit from $2.4 billion in increased utility revenues from EV charging demand, which is offset by $0.4 billion for the Public Service 2024–2026 TEP program and $0.9 billion of power supply costs for serving increased EV charging demand.

FIGURE 5: TRANSPORTATION ELECTRIFICATION RATEPAYER IMPACT MEASURE RESULTS



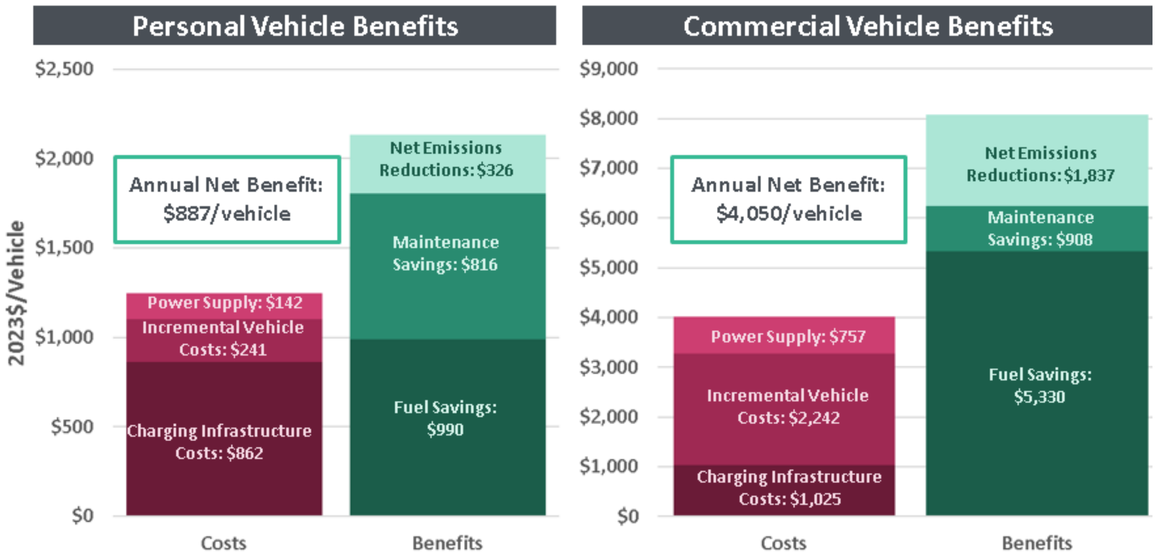
Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.

Figure 6 shows the annual benefits and costs of transportation electrification per EV adopted. To develop these estimates, we levelize the benefits and costs incurred over the 20-year study by the number of vehicles adopted during that time.[17] We estimate annual net benefits of $887 per personal EV and annual net benefits of $4,050 per commercial EV.[18] For both personal and commercial EVs, fuel savings represent the largest benefit stream at $1,000/year per personal EV and $5,300/year per commercial EV. The net benefit is higher for commercial EVs due to higher vehicle miles traveled (VMT) and lower gas mileage on average for commercial vehicles. Further information on the assumption used for both personal vehicles and commercial vehicles can be found in Appendix A.

17 To obtain the annual levelized values per vehicle, we calculate the present value of all benefit and cost streams and divide their sum by the present value of the total number of EVs in operation in each year. We perform this calculation for personal and commercial vehicles separately. The levelized per vehicle-year values can be multiplied by the vehicle lifetime to estimate the net benefits per vehicle over its lifetime.

18 The commercial vehicle calculation relies on the weighted average of all benefit and cost streams from the different types of commercial vehicles we modeled including TNC vehicles, other commercial LDVs, MDVs, school buses, and other HDVs. Further information on the specific assumptions we used to model each of these types of vehicles can be found in Appendix A.

FIGURE 6: ANNUAL SOCIETAL NET BENEFITS PER EV ADOPTED



Sources and Notes: All costs shown in 2023$ with cash flows discounted at the Public Service nominal ATWACC of 6.42%. The figure shows net benefits per vehicle in operation between 2024 and 2043. Vehicles are assumed to be replaced at the end of their lifetime. Incremental vehicle costs are shown net of federal tax credits. The net emissions reduction bar includes the increased emissions from the electricity system as well as the decreased emissions from fuel savings.

Figure 7 shows the annual impact transportation electrification will have on CO_2 emissions in Public Service's territory. Net CO_2 emissions reductions increase from 2024 to 2030 with rising EV adoption, reaching about 1.5 million metric tons by year. The CO_2 emissions reductions from gasoline and diesel fuel greatly exceed the incremental electricity emissions. Moreover, the annual net reduction in emissions increase over time as Public Service further decarbonizes its generation resource mix.[19]

[19] Public Service has a goal of net-zero emissions by 2050.

FIGURE 7: ANNUAL IMPACT OF TRANSPORTATION ELECTRIFICATION ON CO_2 EMISSIONS

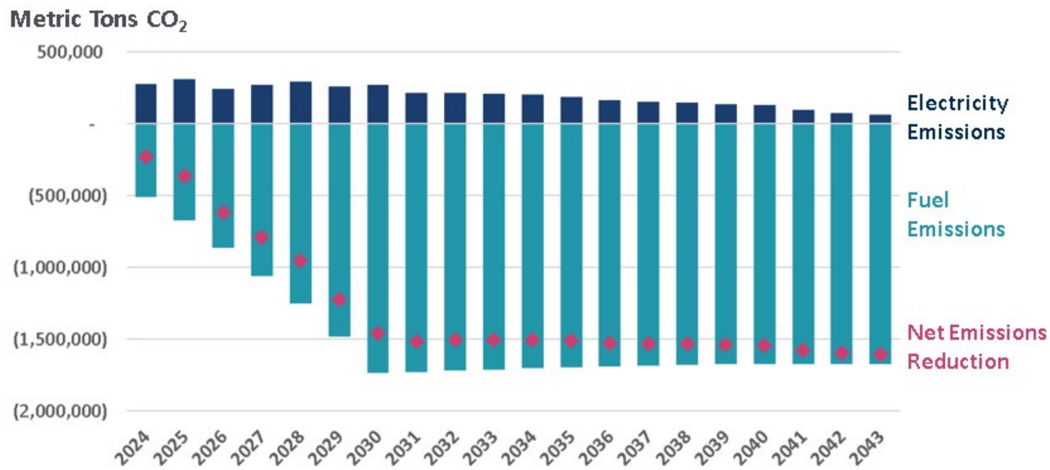


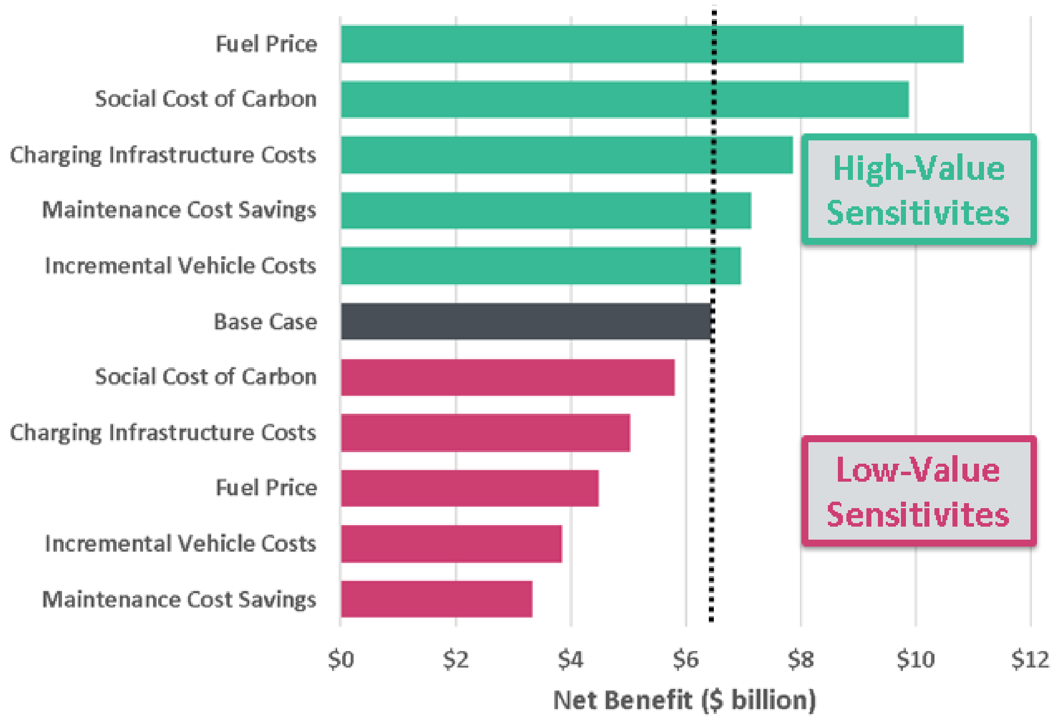
Table 6 below illustrates the cumulative impact of transportation electrification on GHG and criteria air pollutant emissions in Public Service's territory between 2024 and 2042. EV adoption reduces CO_2 emissions by 25.6 million metric tons and also reduces NO_X and PM2.5 emissions. Methane emissions increase slightly by 2,889 metric tons due to increased natural gas-fired power generation to serve EV demand, as do sulfur dioxide emissions. SO_2 emissions also rise slightly due to the very low emissions rates of new ICE vehicle cost.

TABLE 6: CUMULATIVE IMPACT OF TRANSPORTATION ELECTRIFICATION ON EMISSIONS (METRIC TONS)

	Impact on Electricity Emissions	Impact on Fuel Emissions	Net Impact on Emissions
Carbon Dioxide	3,919,340	-29,524,537	**-25,605,197**
Nitrous Oxides	926	-14,664	**-13,738**
Particulate Matter 2.5	75	-475	**-400**
Sulfur Dioxide	501	-201	**+300**
Methane	2,889	0	**+2,889**

The societal net benefits of transportation electrification within Public Service's territory are robust to key assumptions in our analysis. For the key drivers of the results, we establish plausible high- and low-sensitivity assumptions and analyze the change in the net benefits attributable to each. None of the sensitivity assumptions results in negative net benefits. Net benefits are most sensitive to the social cost of carbon and fuel prices on the high end, and the maintenance cost savings and vehicle costs on the low end. For example, assuming lower maintenance cost savings reduce net benefits by \$3.1 billion,[20] while higher fuel prices increases societal net benefits by \$4.4 billion.[21] More information on the assumptions used in the sensitivity analysis can be found in Appendix A.

FIGURE 8: TRANSPORTATION ELECTRIFICATION SOCIETAL COST TEST SENSITIVITY ANALYSIS



Sources and Notes: Each of these sensitivities is designed to be considered individually (i.e., the impacts of the sensitivities are not additive). Details of the sensitivity analysis assumptions are provided in appendices.

[20] To develop our "low" assumption for maintenance cost savings, we utilize the assumptions used in the Colorado LDV Electrification Roadmap. For MHDVs, our "low" assumption is 30% below the base case projections.

[21] To develop our "high" assumption for fuel prices, we utilize the gasoline and diesel prices from the EIA Annual Energy Outlook 2023 "High oil price" scenario.

IV. Conclusion

The objective of this study of transportation electrification in the Public Service territory in Colorado is to inform the Colorado PUC and Public Service stakeholders on the expected costs of reaching Colorado's 2030 transportation electrification goal and the benefits that result from electrification within Public Service's territory, accounting for the costs of the 2024–2026 TEP.

Our analysis demonstrates the significant net benefits to increasing EV adoption in Public Service's territory to meet Colorado's 2030 policy goals. Increasing EV adoption through 2030 will result in $6.4 billion of net societal benefits. The primary benefits of transportation electrification are avoided gasoline and diesel costs ($7.6 billion) and avoided maintenance costs ($4.6 billion) with $2.9 billion in societal benefits for reduced GHG and criteria air pollutant emissions. The societal net benefits translate to about $900 per year of annual benefits for each personal EV adopted and $4,000 per year for each commercial EV adopted. Our analysis demonstrates that transportation electrification net benefits are robust across a range of assumptions with fuel prices and maintenance cost savings having the most significant impact on the results.

EV adoption will also provide net benefits to EV adopters and other participants (including property owners and other charger developers) of $2.0 billion. Upfront costs for purchasing an EV and installing charging infrastructure are offset over time by decreased fuel and maintenance costs. Transportation electrification will provide Public Service ratepayers $1.1 billion in net benefits due to additional bill payments offset the additional utility program and power supply costs.

Transportation electrification will significantly reduce net emissions, in particular CO_2 emissions by about 26 million metric tons over a 20-year period and providing over $2 billion of net benefits. The CO_2 emissions reductions from increased electricity demand for EV charging is significantly lower than emissions from gasoline and diesel fuel. As Public Service further decarbonizes its generation resource mix to reach net-zero emissions by 2050, the annual net reduction in emissions increase over time.

Appendix A: Costs and Emissions Assumptions

Appendix A contains further detail on the methodology and data sources used to develop the forecast of power system and transportation costs and emissions rates used in this study.

ELECTRIC SECTOR COST AND EMISSIONS PROJECTIONS

To evaluate the power system impacts of EV adoption, we primarily utilize results from Public Service's recent resource planning studies for the February 2023 Update to the Colorado Clean Energy Plan.[22] Public Service provided hourly marginal generation costs for 2024 through 2043 to estimate the cost of generating electricity (i.e., fuel costs and variable O&M costs) to serve incremental EV charging demand. The average hourly marginal generation costs increase from $18/MWh in 2024 to $39/MWh in 2043.

We also estimated the incremental costs of procuring additional renewable energy resources to meet Public Service's goal of serving 80% of its demand with renewable energy.[23] We estimated incremental costs of new wind generation resources in Colorado to be about $10/MWh.[24]

To estimate the impact of changes in electricity peak demand on the costs of generation capacity and distribution capacity, Public Service provided long-term marginal costs of generation capacity of $56/kW-year and distribution facilities of $48/kW-year as reported in Public Service's tariff.[25] We assume that these costs escalate with inflation at 2.2% per year over the timeframe of our analysis. We assume an 18% reserve margin, consistent with Public Service's most recent Energy Resource Plan, to estimate the impact of EV demand on generation capacity needs.[26] We assume 4.5% energy line losses and 9.0% capacity line losses.[27]

22 Xcel Energy, Colorado's Clean Energy Plan: February 2023 Update, February 2023.

23 We assume that Public Service will purchase additional renewable energy generation to serve incremental EV charging demand and meet its 80% renewable energy goal. The incremental cost is equal to the all-in levelized costs of wind less the average wind avoided generation costs, which is based on a Colorado wind generation profile from NREL's Standard Scenarios and Public Service's marginal generation costs.

24 Based on bid prices for onshore wind reported by Tri-State for the Public Service territory, see: Tri-State Generation & Transmission Association, 2022 All-Source Solicitation 30-Day Report, 2020 Electric Resource Plan, Proceeding No. 20A-0528E, October 17, 2022.

25 Public Service currently estimates $0 marginal cost of transmission. Public Service Company of Colorado, Economic Development Rate: Schedule EDR, July 20, 2021, p. 7.

26 Public Service Company of Colorado, 2021 Electric Resource Plan and Clean Energy Plan, March 31, 2021, p. 35.

27 Energy line losses assumption comes from Energy Information Administration, Colorado State Energy Profile, Table 10. We assume capacity line losses are double the energy line losses.

We estimate the power sector emissions using projected emissions rates for CO_2, methane, SO_2, and NO_x, and PM2.5. Public Service provided hourly average emissions rates for CO_2 and annual average estimates for SO_2 and NO_x based on recent resource planning studies. Based on our experience, the average CO_2 emissions rates reported by Public Service of 0.35 tons/MWh in 2025, 0.12 tons/MWh in 2030, and 0.08 tons/MWh in 2040 align with the marginal CO_2 emissions rates for a system that will serve 80% of incremental demand with additional wind and solar generation resources.[28] For PM2.5, we use the U.S. EPA's AVERT model to estimate 2024 emissions rate because Public Service does not track PM2.5 emissions in its resource planning studies, and apply a declining rate based on the trend in SO_2 emissions.[29] For estimating methane emissions, we assume methane leakage from natural gas pipelines at the rate of 0.25% of natural gas consumption consistent with the previous assumptions used in the 2021 Public Service Energy Resource Plan filing.[30]

TABLE A-1: FORECAST OF AVERAGE ELECTRICITY GENERATION EMISSIONS RATES (2025—2040)

Pollutant	2025	2030	2035	2040
CO_2 (tons per MWh)	0.31	0.11	0.074	0.068
NO_X (lbs. per MWh)	0.31	0.060	0.028	0.023
SO_2 (lbs. per MWh)	0.28	0.014	<.001	<.001
PM2.5 (lbs. per MWh)	0.043	0.005	<.001	<.001

Sources:
CO_2 emissions rate is from Public Service's hourly forecast for short-term power sector average emissions.
NO_x and SO_2 emissions rates are from Public Service.
The PM2.5 emissions rate is based on NREL's AVERT tool adjusted for Colorado.

TRANSPORTATION FUEL COST AND EMISSIONS PROJECTIONS

To estimate the avoided costs of reduced transportation fuel demand, we rely on long-term projections for wholesale motor gasoline and diesel prices (excluding distribution costs and federal and local taxes) from the EIA's 2023 Annual Energy Outlook for the Mountain Census region, which includes Colorado, using the Reference Case for the base assumption, the High Oil Price Case for the high assumption, and the Low Oil Price Case for the low assumption.[31]

[28] Hledik, et al., Pepco's Climate Solutions 5-Year Action Plan: Benefits and Costs, January 2022, p. 46.

[29] U.S. EPA, Avoided Emissions and Generation Tool (AVERT), 2022.

[30] Public Service Company of Colorado, 2021 Energy Resource Plan and Clean Energy Plan Phase 2: Updated Modeling Inputs and Assumptions, November 2022 at 9.

[31] U.S. Energy Information Administration, Annual Energy Outlook 2023 Reference Case, March 2023 at Table 57.8 and Table 12.

To estimate the avoided CO_2 emissions from a reduction of the use of fossil fuels, we use CO_2 emissions rates reported by the EIA.[32] We assume an emissions rate of 19.37 pounds per gallon of gasoline and 22.45 pounds per gallon of diesel.

To derive criteria air pollutant emissions rates for transportation fuels, we use the EPA's emissions rate standards for new light-duty vehicles of 0.03 grams per mile for NO_x and 0.003 grams per mile for PM2.5.[33] We convert these values to pounds per gallon using our average vehicle efficiency forecast over the study period of 37.0 miles per gallon for LDVs, arriving at 0.0024 pounds per gallon of NO_x and 0.00024 pounds per gallon of PM2.5.[34] We perform similar calculations for diesel fuels which results in 0.0117 pounds per gallon of NO_x and 0.00006 pounds per gallon of PM2.5. For SO_2 emissions rates, we use the current EPA standards of 10 ppm in gasoline, the molar mass of sulphur and SO_2, and the density of gasoline to estimate 0.00012 pounds per gallon of SO_2. We perform a similar calculation for diesel to estimate 0.00021 pounds per gallon of SO_2.[35]

VEHICLE COSTS

There is currently a price premium on the upfront cost of an electric vehicle when compared to an equivalent ICE vehicle, primarily due to the cost of the battery. To calculate the current EV purchase premium for LDVs, we rely on the Colorado LDV Electrification Roadmap.[36] Specifically, we assume that an electric sedan costs $5,595 more than an ICE sedan and an electric SUV costs $7,835 more than an ICE SUV.[37] The LDV Roadmap finds that the EV purchase premium declines over time at a compound annual growth rate of 6.7% real, which is a proxy for technological innovation that we assume is likely to occur in the future.

The incremental cost of light trucks, delivery trucks, school buses, and refuse trucks is based on a 2022 U.S. Department of Energy report designed to improve consistency in EV modeling.[38] We assume that electric light trucks and delivery trucks currently have a purchase premium of

32 U.S. Energy Information Administration, Carbon Dioxide Emissions Coefficients, October 5, 2022.

33 U.S. Environmental Protection Agency, Light Duty Vehicle Emissions, accessed November 1, 2022.

34 U.S. Energy Information Administration—Independent Statistics and Analysis, AEO 2022, Table 7.

35 U.S. Environmental Protection Agency, Tier 3 Motor Vehicle Emission and Fuel Standards, accessed February 13, 2023. Densities of gasoline and diesel are roughly 6 lbs/gallon and 7 lbs/gallon. One gram of sulphur creates 2 grams of SO2 in air.

36 Colorado Energy Office, Colorado Light-Duty Vehicle Electrification Roadmap, April 2022, p. 127.

37 Value is in 2020 dollars.

38 U.S. Department of Energy, 2022 Incremental Purchase Cost Methodology and Results for Clean Vehicles, December 2022.

$19,500 and $34,500, respectively, while school buses and other HDVs have a purchase premium of $297,500.[39] We assume that MHDV EV incremental vehicle decrease by 5.6% real over time.[40]

We estimated low and high vehicle cost assumptions for the sensitivity analysis by assuming in the low case that incremental vehicle cost declines at 8% real per year and, in the high case, the costs remain constant in nominal terms (or decline at 2.2% real per year).

We subtract the value of the federal tax credit applicable in each year from the per-vehicle premium, per the extension to the Section 30D tax credits for EVs outlined in the Inflation Reduction Act. [41] We assume each personal EV will receive $3,750 (in nominal dollars) in tax credits, which is 50% of the maximum tax credit of $7,500. This assumption aims to capture that some EV purchases will not qualify for the full amount due to eligibility requirements related to income, domestic vehicle assembly, and other factors.[42] Commercial vehicle tax credits also are calculated in accordance with the Inflation Reduction Act.[43] The tax credit for commercial MHDVs is set as the minimum of the following three criteria: $40,000, 30% of the total purchase price, or the incremental purchase price of the EV over a similar ICE vehicle. The tax credit for commercial LDVs is modeled using the same approach, except with a $7,500 price cap instead of $40,000. The maximum payment for commercial LDVs is also derated 50% to $3,750.

Maintenance cost savings are based on ANL's AFLEET tool and are applied to the avoided maintenance costs assumption for both personal and commercial vehicles.[44] We calculate savings of $0.06/mile for LDVs, $0.07/mile for transportation network company (TNC) vehicles and commercial LDVs, $0.08/mile for MDVs, $0.37/mile for school buses, and $0.03/mile for HDVs for the base assumption.[45] For the low assumption, we use maintenance cost savings from the Colorado LDV Electrification Roadmap for all LDVs and light trucks, which is

---

39 *Id.* at Table 5. Light trucks are assumed to have the incremental purchase cost at a pickup truck. Delivery Trucks are assumed to have the incremental purchase price of a class 4–6 truck. School buses and refuse trucks are assumed to have the incremental purchase price of a class 8 Truck.

40 ICF, Comparison of Medium and Heavy Duty Technologies in California, 2019.

41 U.S. Senate, H.R. 5376—Inflation Reduction Act of 2022, August 2022.

42 Alternative Fuels Data Center: Electric Vehicle (EV) and Fuel Cell Electric Vehicle (FCEV) Tax Credit (energy.gov). Also see Electrification Coalition IRA EV Tax Credits Fact Sheet, 2022. SAFE_1-sheet_Webinar.pdf (electrificationcoalition.org)

43 U.S. Senate, H.R. 5376—Inflation Reduction Act of 2022, August 2022.

44 Argonne National Laboratory. AFLEET Tool—Argonne National Laboratory (anl.gov).

45 All values are reported in 2020 dollars. We model an annual increase at the assumed inflation rate of 2.2%.

$0.017/mile for LDVs, $0.018/mile for light trucks, and 30% lower cost savings for MHDVs.[46] For the high assumptions, we assume vehicle maintenance cost savings increases by 15% compared to the base assumption.

CHARGING INFRASTRUCTURE COSTS

We utilize the charging infrastructure cost assumptions for EVSE and EVSI that Public Service developed for the 2024–2024 TEP. Table A-2 below shows the projected costs for each charger type included in our model. We assume charging infrastructure costs remain constant in nominal terms (decline in real terms) throughout our study period from 2024 to 2043. We account for federal tax credits for charging infrastructure. Single-family home residential chargers qualify for the minimum of $1,000 per port or 30% of the EVSE costs. Commercial chargers qualify for the minimum of $100,000 per port or 30% of the EVSE costs, with a 50% reduction in the value to account for limits placed on chargers that can receive the tax credits. For the sensitivity analysis, we assume that charger costs are 30% lower or higher than the base case in the low and high cases, respectively.

[46] Colorado Energy Office, Colorado Light-Duty Vehicle Electrification Roadmap, April 2022, p. 127.

TABLE A-2: ASSUMED CHARGER COSTS

Charger Type	EVSE Cost	EVSI Cost	Total Cost
Private Charging			
SFH L1	$0	$0	$0
SFH L2	$787	$1,500	$2,287
MFH L1	$0	$0	$0
MFH L2	$5,000	$11,670	$16,670
MFH DCFC	$85,650	$36,500	$122,150
Workplace L2	$4,000	$11,670	$15,670
Workplace DCFC	$85,650	$36,500	$122,150
Fleet L2	$4,000	$11,670	$15,670
Fleet DCFC	$85,650	$36,500	$122,150
School Bus L2	$4,000	$11,670	$15,670
School Bus DCFC	$65,000	$130,000	$195,000
Transit Bus L2	$4,000	$11,670	$15,670
Transit Bus DCFC	$65,000	$130,000	$195,000
Public Charging			
Hub L2	$8,000	$22,000	$30,000
Hub DCFC	$90,344	$170,000	$260,344
Market L2	$8,000	$22,000	$30,000
Market DCFC	$90,344	$170,000	$260,344
Shared SFH L1	$0	$0	$0
Shared SFH L2	$5,000	$11,670	$16,670
Shared SFH DCFC	$85,650	$36,500	$122,150

Sources and Notes: Charger costs are based on the assumptions used by Public Service in the development of the 2024–2026 TEP. Costs are assumed to stay constant in nominal terms over time.

SOCIETAL COST OF EMISSIONS

We apply a value for the avoided CO_2 emissions at the societal cost of carbon (SCC). In particular, we rely on the SCC estimated in the most recent Interagency Working Group report using a 2.5% real discount rate.[47] Public Service relied on the same SCC line with recent precedent by Public Service. [48] Due to the uncertainty in the SCC value, we also estimate the value of avoided CO_2 emissions at the lower values reported by the Interagency Working Group based on a 3.0% real discount rate and the higher values reported by the U.S. Environmental

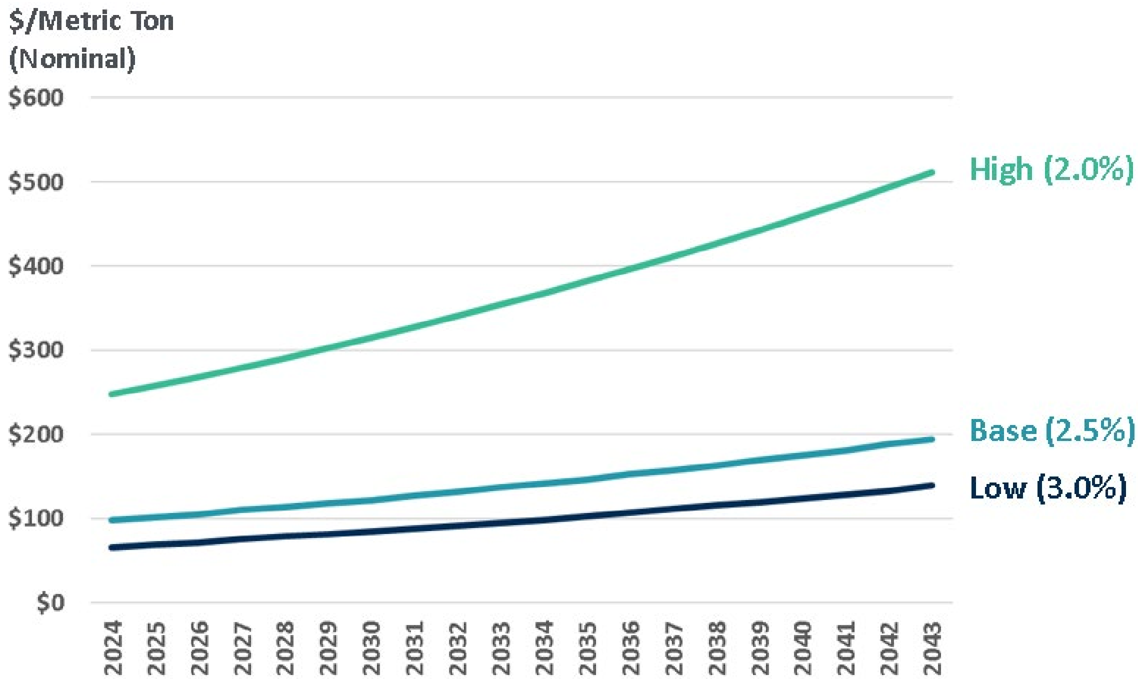
[47] Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates under Executive Order 13990, February 2021.

[48] See Public Service's 2024–2026 Strategic Issues application submitted to Proceeding No. 22a-0309EG.

Protection Agency (EPA) in its draft November 2022 report, which is based a 2.0% real discount rate.[49]

Figure A-1 below shows the SCC values used in our analysis. The base SCC used in the analysis is $122/metric ton in 2030 (nominal dollars) with a low value of $85/metric ton and a high value of $315/metric ton.

FIGURE A-1: PROJECTED SOCIAL COST OF CARBON



Notes: Values shown in nominal dollars. Percentages indicate real discount rate assumed when calculating the costs.

We rely on the same source from the Interagency Working Group for the social cost of methane emissions from natural gas generation, which is $2,500/metric ton (in 2020 dollars) in 2030.

The literature on the value of reducing criteria air pollutants contains a wide range of potential estimates. The societal costs of criteria air pollutants vary depending on many factors, including the source, location, and specific content of the emissions. For consistency across sources, we use estimates for several pollutants and point sources that are based on regulatory filings by the National Highway Traffic Safety Administration (NHTSA) in its proceedings related to the

49 U.S. Environmental Protection Agency, Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances, accessed May 2023.

updated Corporate Average Fuel Efficiency (CAFE) standards.[50] Given the significant uncertainty in the societal costs of criteria air pollutants, we use the lower end of the range to estimate the benefits of transportation electrification. The result is a conservative estimate of benefits from reduced criteria air pollutants.

FIGURE A-2: SOCIETAL COSTS OF CRITERIA AIR POLLUTANT EMISSIONS

Power Sector Costs ($/ton)			Transportation Costs ($/ton)		
NOx	**SOx**	**PM2.5**	**NOx**	**SOx**	**PM2.5**
$8,528	$57,657	$216,212	$9,009	$156,153	$888,873

Notes: Values shown in 2023 dollars.

DISCOUNT RATES

For the SCT, we use a 2.5% real discount rate in our net present value calculations to discount all future cost and benefit streams, consistent with recent precedent of Public Service on the discount rate. We selected this value to be consistent with the discount rate that is used to calculate the social cost of carbon and social cost of methane. We calculate the nominal discount rate of 4.76% by accounting for expected long-term inflation of 2.2% per year.[51] For the PCT and RIM, we use Public Service's after-tax weighted average cost of capital of 6.42%.[52]

[50] National Highway Traffic Safety Administration, Technical Support Document: Final Rulemaking for Model Years 2024-2026 Light-Duty Vehicle Corporate Average Fuel Economy Standards, March 2022.

[51] The following formula is used: Nominal discount rate = Real discount rate + Expected inflation + (Real discount rate × Expected inflation).

[52] Provided by Public Service.

Appendix B: System Impact Assumptions

Appendix B provides a description of key assumptions used in the model to estimate the system impacts of transportation electrification. We combine estimated changes in the consumption of electricity, gasoline, or diesel with the marginal system costs and emissions described in Appendix A to produce an estimate of the net benefits of transportation electrification.

PERSONAL VEHICLE EV ADOPTION

We estimate the system impacts of personal EV adoption based on the following assumptions:

- **Vehicle Types:** We assume a mix of EV models (e.g., sedans, SUVs), types (fully electric Battery Electric Vehicles, or BEVs, and partially electric Plug-In Hybrid Electric Vehicles, or PHEVs), and electric-drive ranges. The most common vehicles are BEV sedans (26% of all EVs) and BEV SUVs (62%), with the remaining 12% being a mix of PHEVs.[53]
- **Annual Mileage:** We estimate annual average VMT of about 11,000 miles per vehicle.[54] We distribute this annual VMT across quarters of the year and weekdays/weekends according to historical LDV driving patterns. We assume BEVs drive 100% electric miles, while PHEVs drive between 37% and 55% electric miles annually depending on the vehicle type and battery size.[55]
- **Vehicle Efficiency:** We assume an average efficiency of 2–4 miles per kWh in 2024 and adjust the efficiency by quarter to account for the impact of temperature.[56] We assume that all new EVs adopted in a given year are 4.6% more efficient than vehicles adopted in the year prior.[57] For calculating the avoided gasoline usage, we use the projected average efficiency of internal combustion engine light duty vehicles from the AEO 2023 Reference

[53] BEV vs. PHEV split is sourced from the Colorado LDV Electrification Roadmap. SUV vs. Sedan split is based on iSeeCars analysis of vehicle sales in each state.

[54] Based on the assumption for 2030 used in the Colorado LDV Electrification Roadmap, April 2022.

[55] Percent of electric VMT assumptions are sourced from EVI Pro-Lite, an NREL tool. https://afdc.energy.gov/evi-pro-lite

[56] ICCT, Assessment of Light-Duty Electric Vehicles and Consumer Benefits in the United States in the 2022-2035 Timeframe, October 2022. Efficiencies differ based on the range of the vehicle and for BEVs vs. PHEVs.

[57] *Id.* Based on the 2022 and 2030 vehicle efficiencies shown in Table 5, we calculate the average annual rate of efficiency improvement for BEV-150 sedan, BEV-250 sedan, BEV-150 SUV, BEV-250 SUV, PHEV-20 sedan, PHEV-20 SUV, PHEV-50 sedan, and PHEV-50 SUV and calculate the simple average across each vehicle type.

Case.[58] The Reference Case forecasts a fuel efficiency of 32.3 miles/gallon of gasoline in 2024, increasing to 39.2 miles/gallon by 2043.

- **Charger Load Profiles:** We develop an average 24-hour load profile for both BEVs and PHEVs by charger type based on daily charging patterns from EVI Pro-Lite. We distribute the charging electricity demand assuming 80% of charging occurs at home with the remaining 20% of demand equally split between workplace and public charging.[59] We assume that 60% of public charging occurs at DCFCs.[60]

COMMERCIAL FLEET EV ADOPTION

We estimate the system impacts of commercial EV adoption based on the following assumptions:

- **Vehicle Types**: We model five types of commercial vehicles as shown in Table B-1 below.[61]
- **Annual Mileage and Efficiency:** See a summary of our assumptions in Table B-1 below.
- **Charger Load Profiles:** We developed separate charging profiles for the TNC fleet, Commercial LDVs, MDVs, HDVs, and School Buses.[62] The commercial LDV class is assumed to be a mix of BEVs and PHEVs while the rest of the commercial vehicles types included in our analysis are assumed to be all BEVs. All commercial vehicles are assumed to charge 100% of the time at fleet chargers with the exception of the TNC fleet which charges 35% of the time at home chargers and the remaining 65% of the time at public DCFC ports.[63]

[58] U.S. Energy Information Administration, Annual Energy Outlook 2023 Reference Case, March 2023 at Table 57.8.

[59] NREL, Incorporating Residential Smart Electric Vehicle Charging in Home Energy Management Systems, April 2021.

[60] 60% value shown above is only for BEVs. We assume that PHEVs do not charge at DCFCs at all.

[61] See Section II.D for information on the number of vehicles assumed to be in operation for each vehicle type.

[62] Base 24 hour charging profiles were taken from the following sources. TNC profile: Jenn, Alan, Emissions Benefits of Electric Vehicles in Uber and Lyft Services, August 2019. Commercial LDV: California Energy Commission, California Investor-Owned Utility Electric Load Shapes, April 2019. MDV: California Energy Commission, Staff Report: Implementation of AB2127 Electric Vehicle Charging Infrastructure Assessments, January 2021. HDV: California Energy Commission, California Investor-Owned Utility Electric Load Shapes, April 2019. School Bus: Developed based off a typical driving schedule of a school bus with a dedicated DCFC charger.

[63] International Council on Clean Transportation, Charging Infrastructure Requirements to Support Electric Ride-Hailing in U.S. Cities, March 2020.

TABLE B-1: VEHICLE ANNUAL MILEAGE AND 2024 EFFICIENCY

Vehicle Type	Annual Mileage (miles/year)	ICE Efficiency (miles/gal)	EV Efficiency (miles/kWh)
Personal LDV	10,957	32.3	2.0-4.0
TNC Vehicle	69,394	32.3	2.8-4.0
Commercial LDV	17,650	27.7	2.0-4.0
Delivery Truck	48,000	8.8	0.72
HDV	78,000	6.6	0.60
School Bus	12,000	7.9	0.65

Sources and Notes: Range of EV efficiencies for Personal LDVs and other vehicles reflect efficiencies of different types of vehicles, including sedans or SUVs and longer- or shorter-range vehicles.

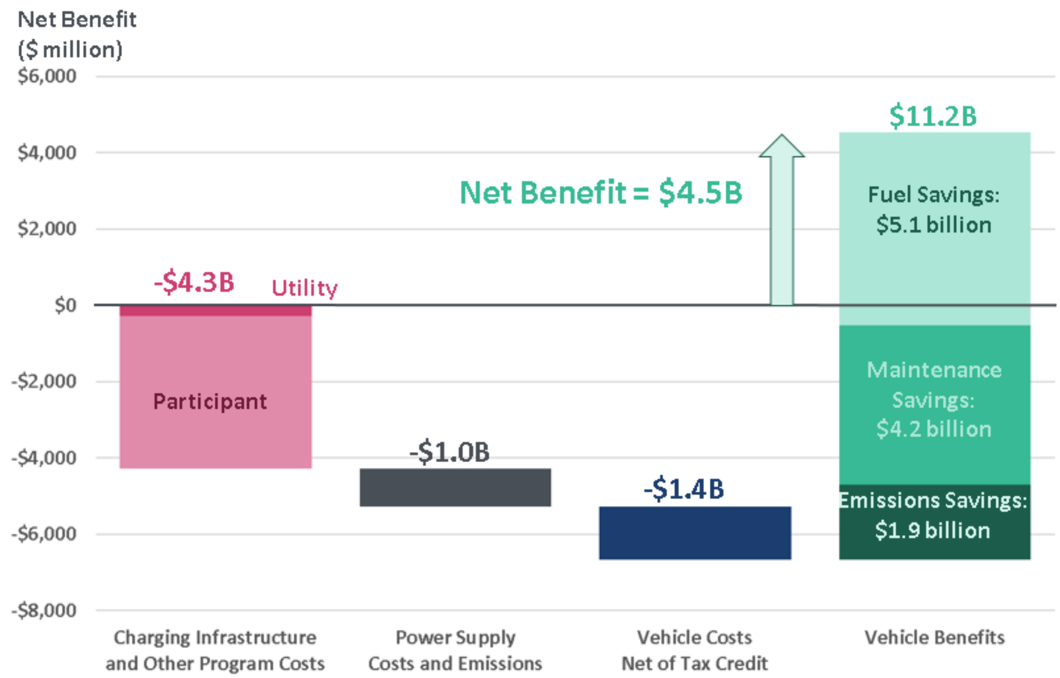
MANAGED CHARGING PROGRAMS

We include the impact of the managed charging programs Public Service is proposing through the 2024–2026 TEP. We utilize charging profiles provided by Public Service for their Optimize Your Charge and Charging Perks programs based on data from participants in the programs.

Appendix C: Category-Specific Results

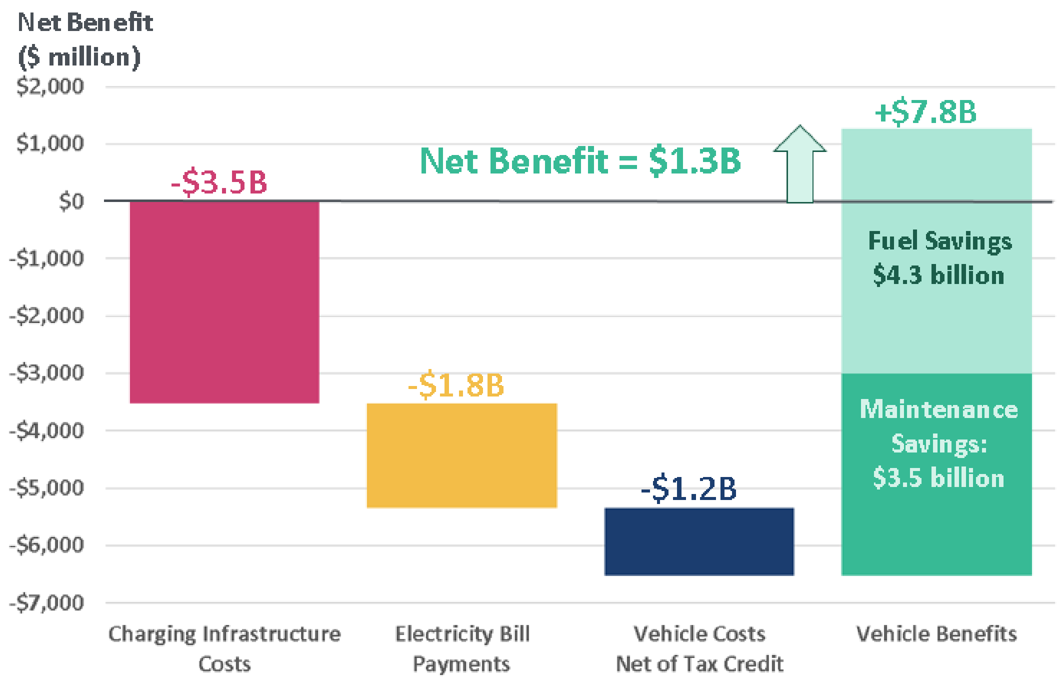
A. Personal Vehicles

FIGURE C-1: PERSONAL VEHICLE SOCIETAL COST TEST RESULTS



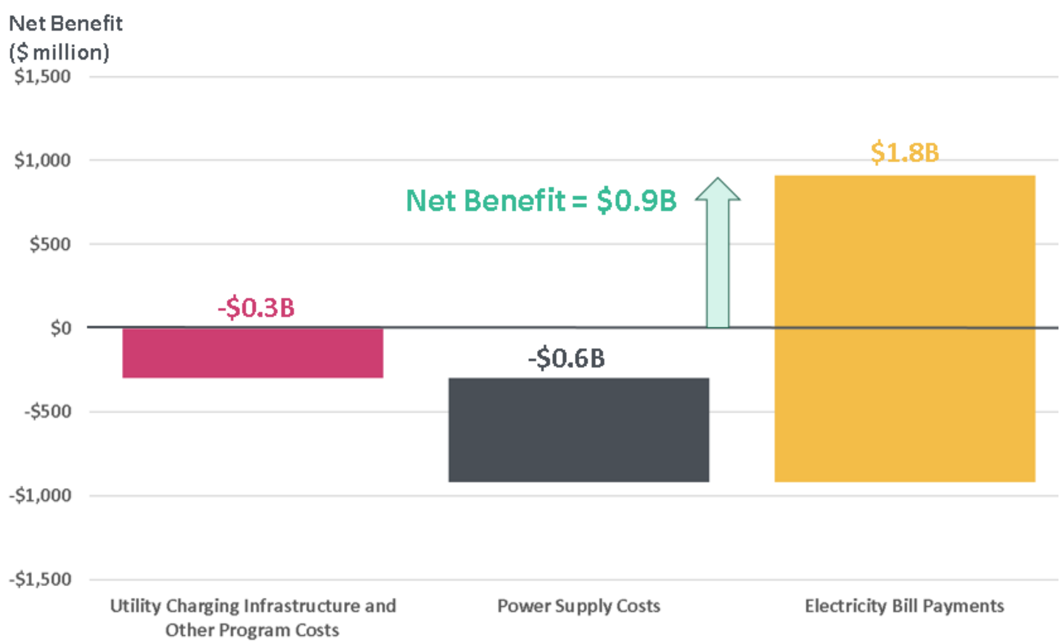
Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 4.76%. Charging infrastructure costs include both EVSE and EVSI.

FIGURE C-2: PERSONAL VEHICLE PARTICIPANT COST TEST RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.

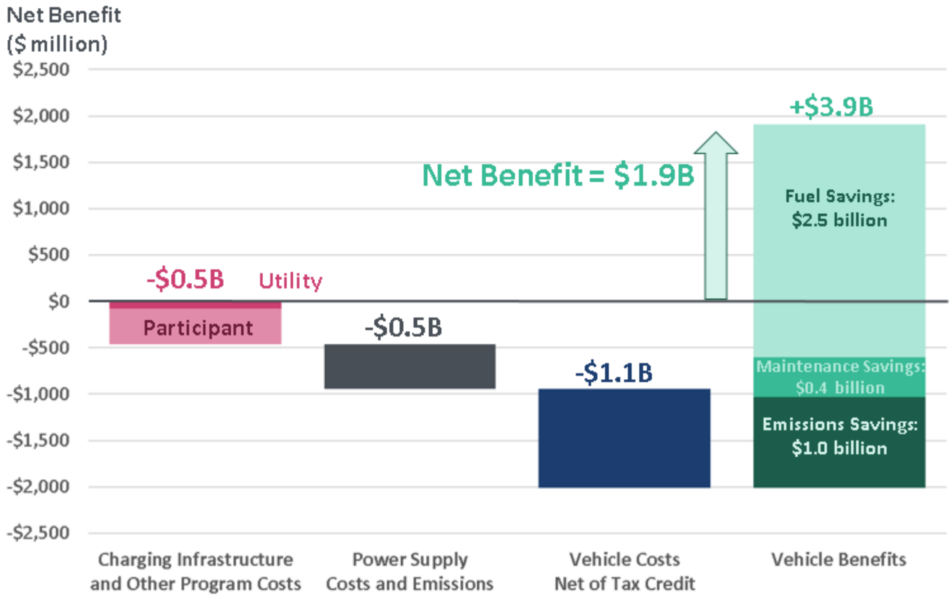
FIGURE C-3: PERSONAL VEHICLE RATEPAYER IMPACT MEASURE RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.

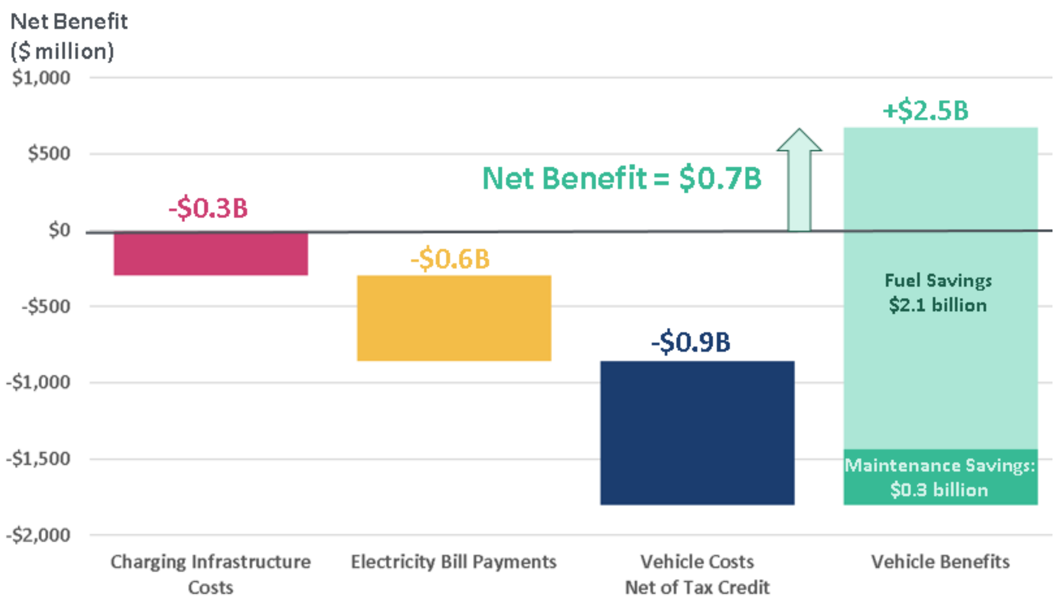
B. Commercial Vehicles

FIGURE C-4: COMMERCIAL VEHICLE SOCIETAL COST TEST RESULTS



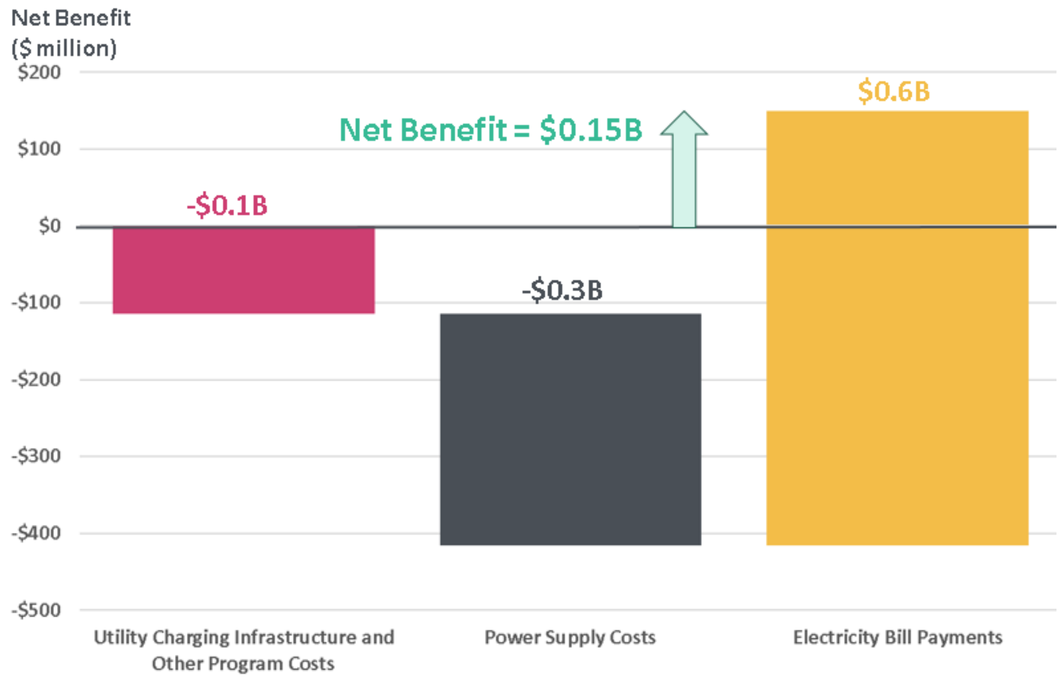
Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 4.76%. Charging infrastructure costs include both EVSE and EVSI.

FIGURE C-5: COMMERCIAL VEHICLES PARTICIPANT COST TEST RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.

FIGURE C-6: COMMERCIAL VEHICLES RATEPAYER IMPACT MEASURE RESULTS



Sources and Notes: All costs shown as the present value as of 2023 of cash flows over the 20-year study period discounted at the Public Service's nominal ATWACC of 6.42%. Charging infrastructure costs include both EVSE and EVSI.